MALCOLM PIRNIE

INTEROFFICE CORRESPONDENCE

To: Bruce Fidler, NNJ **Date:** October 11, 2005

Copy: Len Warner, WHI; Ed Garvey, NNJ

From: Shane McDonald, KOP; AmyMarie Accardi-Dey, WHI

Re: High Resolution Coring Program Concise Description

The following memorandum describes concisely the methods, purpose, and benefits of the high resolution coring program. There are several key project questions and issues that can best be addressed through the evaluation of dated high resolution cores. The following points are examples of the utility of the high resolution cores:

- *High resolution cores document the history of contaminant inputs, transport and transformation.* Properly dated and analyzed cores provide a record of historical contaminants carried by the suspended matter. Several cores taken along the river will document the spatial extent of contaminant transport, identifying areas where sources arise and areas subjected to transport from upstream. Once in the sediments, contaminant transformation over time can be documented by comparing various aged core layers. Only by knowing the contaminants' past behavior will it be possible to forecast their future behavior. For example, detection in the core of consistent magnitudes and ratios of chemical concentrations over time, even after sources have been eliminated, suggests that historically released contaminants continue to be mobile in the river. Conversely, a steady decline of contaminants and changes in constituent ratios shows that contaminants and sediments are relatively stationary. Because the low resolution cores do not have the temporal discretization, they cannot be used to discern these trends.

- *Differences among contaminant histories in high resolution core records can document the introduction and approximate location of contaminant sources.* Knowing where external contaminant loading occurs is necessary to assess whether remediation will be effective and/or whether sediments will become re-contaminated from on-going loads. High resolution cores offer the best empirical means to show which contaminants are introduced from both upstream and downstream relative to those remaining from historical discharges. Evaluation of the dated high resolution cores can show if contaminants so introduced will significantly propagate through the river and at what rate.

- *High resolution cores can document the degree to which contaminated sediments are mobilized in the river during extreme flows is critical in evaluating remedial strategies*. Although SedFlume experiments determine the conditions that will mobilize sediment, and modeling predicts sediment and contaminant movement under these conditions, dated high resolution cores offer the best empirical evidence that those conditions have or have not existed in the river. The sediment's response to extreme flow events is not discernible from low resolution cores.

- *Contaminant histories and associations derived from high resolution cores can provide a basis to limit future analytical costs.* Knowledge of the contaminant distribution within the river is a linchpin to project decision-making; however chemical analyses represent a large portion of the cost to assess contaminant distribution. The high resolution cores provide the means to define marker compounds that may be used to reduce the number of compounds analyzed in any one sample (assuming there is not another reason beyond contaminant distribution, such as risk assessment, to analyze for specific compounds). This analyses-minimizing process could assist in conserving resources during the planned extensive low resolution core program in 2006.

More generally, the information acquired during the high resolution coring program will be used to:

- Understand contaminant distribution in the Lower Passaic River as a function of distance along the river.
- Understand long term fate of contaminants within the sediments, such as long term transformation processes.
- Document the effects of past events, such as the impacts of major storm events on sediment beds (as an empirical indicator of sediment stability during extreme events) and the introduction of contaminants to the river.
- Provide data on time-dependent functions, *e.g.*, mixing, and source inputs.
- Augment the calculation of contaminant mass and sediment volumes based on finer sampling intervals and more-accurate estimation of sedimentation rates than can be achieved by low resolution cores and bathymetric surveys alone, since these will not provide a complete historical picture of the contaminant inputs or accumulation.
- Provide additional data to understand the complex interactions of contaminants, sediments, time, river flow and tide, and adjacent water bodies.
- Provide information on current sources and loads as context for assessing the effectiveness of remedial alternatives, including providing a basis to evaluate the potential for recontamination from adjacent water bodies.
- Provide information to update the conceptual site model.

The high resolution coring program will provide an approach for determining the temporal distribution of contaminant loads in the Lower Passaic River and for understanding when and where contaminants entered the river as well as when and where contaminants traveled once they were released. The program also provides the information needed to assess the re-suspension of contaminants during extreme events (the best measure of sediment stability in the river) and provides possible sediment transport modeling calibration targets. The high resolution coring program ***is not*** a method to determine precisely the lateral and vertical extent of contamination, although the data will shed some light on contaminant distribution throughout the river and at what depth/time horizon the greatest amounts of contamination may occur.

The high resolution coring program begins by locating target areas where deposition is presumed to be continuous (based on a review of historic bathymetric surveys, maps of sediment type produced from side scan sonar surveys, and the findings of investigations conducted by others) and by testing those locations for beryllium-7, a natural indicator of depositional processes. Beryllium-7 enters the water column through atmospheric deposition and is short-lived; therefore its presence indicates that deposition has occurred within the last six months. The high resolution coring locations were also selected in relation to specific features of the Lower Passaic River, including confluences with tributaries and the pool above the Dundee Dam. The beryllium-7 testing provides an additional line of evidence that sediment deposition is currently occurring in the target locations. Sediment cores are then collected at the target locations where high concentrations of beryllium-7 are detected, classified in the field by a geologist, and brought to the field facility for processing. The geologist indicates to the field facility at what depth sediments transition from recent to pre-industrial, usually demarked by a change in sediment color and texture.

At the field facility, the geologically recent (last 100 years or so) sediments are divided into approximately 40 segments, with the finest segmenting occurring at the top of the core. (Note that additional segments are collected from the pre-industrial sediment). Segments are then analyzed for radiological parameters including cesium-137 and lead-210, to date the sediment core. In brief, cesium-137 appears in sediment beds in layers that correspond to the year 1954, and concentrations peak in the 1963 as a result of nuclear weapons testing fallout. These cesium-137 features associated with these two specific years provide markers in the sediment bed for dating. Lead-210 becomes assimilated into the sediment beds from atmospheric deposition. The natural decay of lead-210 (with a half-life of 22 years) can be used to project the sediment dating timeline into the past about 60 to 80 years. The natural variability of lead-210 input to the watershed provides a less precise measure of time relative to cesium-137. Taken together, the two radioisotopes provide a more robust estimate of sediment chronology than either alone. It is expected that in most cases, the dates derived from cesium-137 will be more accurate than those from lead-210 and so will be used primarily in the ensuing historical data analyses.

Considering that the objective of the high resolution coring program is to reconstruct the depositional history of environmental contaminants in the Passaic River sediments, radionuclide dating of the cores is essential. Due to the industrial history of the Passaic River area and the maintenance of the navigation channel, much of the river sediment has been disturbed by human action (*e.g.*, dredging) in addition to significant storm and flood events, which have the potential to mobilize and displace sediment deposits. The goal of the high resolution coring program is to locate areas where a minimum of disturbance has occurred (sheltered, continuously depositional locations, where feasible), so that the chemical analyses of the core segments can map the depositional history of specific types of contaminants (*e.g.,* the depth/year where maximum concentration was released.) However, only cores containing the 1964 cesium-137 peak can be used to document the Passaic's contaminant loads history.

A core with a discrete cesium-137 peak and a steady decrease in lead-210 represents a continuous depositional environment where the geochemical history of the nearby river can be discerned. Conversely, interruptions or discontinuities in the radionuclide "profile" would indicate an historic dredging or storm event that removed sediment corresponding to a specific period (*e.g.*, a core without a well-defined peak in cesium-137 concentration represents an area that was dredged or disturbed such that sediments deposited in the 1950s were removed). Cores containing continuous deposition will be analyzed for chemical contaminants. In general, the chemical history determined in one high resolution core is considered to represent the chemical history of the surrounding 1 to 2 miles of river, including the integration of contaminants that have traveled into the river section from either up or down stream (*i.e.* you might expect a geochemical difference between cores from upstream and downstream of the confluence with a major tributary such as the Saddle River). Without the radio-dating component, it would be difficult to discern if the vertical extent of the contaminants and their relative concentration maxima represented the actual history of their deposition, since pieces of the sediment record could be missing from the core due to dredging or other benthic disturbances.

Given a complete and successful high resolution coring program, the results should yield contaminant loading and transport histories of the river in the region surrounding each cores. The relative date when a contaminant entered the river or was at peak loading can be determined in each datable core and compared between dateable cores. The comparison of contaminant histories, including ratios of chemicals and chemical signatures, from each core can show where in the river contaminants first appeared, how long they took to spread throughout the Lower Passaic River, the dominant directions of spread, and if the contaminants were re-suspended during storm events. This information is invaluable when assessing contaminant mobility, the effects of adjacent water bodies (*i.e.* Newark Bay) on contaminant distribution, general sediment stability during extreme events, and the effectiveness of future remedial strategies.

Finally, as noted above, the study also may identify marker compounds that can be used during the more extensive 2006 low-resolution coring program to identify "inclusive samples" thereby reducing the number of analyses needed. For example, if DDT is consistently detected deeper in the high resolution cores than dioxin, a field investigation planning decision may be made to require only analysis of DDT for purposes of determining the vertical extent of contaminated sediment.